

ELECTROMAGNET ASSEMBLY FOR ELECTROMAGNETIC APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an electromagnet assembly for use in an electromagnetic apparatus, such as an electromagnetic clutch for use in controlling the transmission of power from an automobile engine to a refrigerant compressor in an automobile air conditioning system. More particularly, it relates to a connecting structure between a connector and a ring case in the electromagnet assembly.

2. Description of Related Art

[0002] Referring to **Fig. 1**, an electromagnet assembly 7, which comprises a ring member 1, a coil bobbin 3, and a ring case 4, is known in the art. Ring member 1 has a toroidal shape having a spool portion, which has an exterior open edge. Coil bobbin 3 has ring member 1 and an electrical wire 2, which is wound around the spool portion of ring member 1. Ring case 4 has an annular groove, an open edge of which is in a direction parallel to its axis. Coil bobbin 3 is inserted into the annular groove of ring case 4. An opening 4a is formed through ring case 4 adjacent to its closed end surface. A connector 5 is disposed on ring case 4 adjacent to its closed end surface and covers opening 4a. A first end 2a and a second end 2b of electrical wire 2 and a first lead 6a and a second lead 6b, which extend to the external electric circuit, are joined, respectively in connector 5. Electromagnet assembly 7, for example, is used in an electromagnetic clutch 9 of a compressor 8 in an automobile air conditioning system, as shown in **Fig. 2**. Electromagnet assembly 7 engages compressor 8 through a ring-shaped plate 10, which is affixed to the closed end surface of ring case 4.

[0003] Referring to **Figs. 3-6**, the connecting structure between connector 5 and ring case 4 and the wiring connecting structure in connector 5 are shown. As shown in **Figs. 3 and 4**, connector 5 has a case 5a having a box shape including a bottom, and cap 5b, which closes an open end of case 5a. Case 5a is fixed to ring case 4 by a pair of first hooks 10a formed on ring shaped plate 10 which engage a pair of first receiving portions 5a<sub>1</sub> formed on case 5a. In an engaging process, first hooks 10a are formed by bending straight portions to engage first receiving portions 5a<sub>1</sub>. Cap 5b is fixed to case 5a by engaging a plurality of second receiving portions 5a<sub>2</sub> formed at case 5a with a plurality of hooks 5b<sub>1</sub> formed at cap

5b. A projection portion 5a<sub>3</sub>, which is formed on case 5a, is inserted into opening 4a. An O-ring 11, which is disposed in an annular groove formed on case 5a, surrounds opening 4a and abuts the closed end surface of ring case 4.

[0004] As shown in **Figs. 4-6**, first end 2a and second end 2b of electrical wire 2 are introduced into opening 4a through holes 1a and 1b formed on an end surface of ring member 1 and are extended into connector 5 through a pair of penetrating holes 5a<sub>4</sub>, which are formed through projection portion 5a<sub>3</sub>. A contact 12 having a first electric connection is connected to an end of second lead 6b, which is inserted into connector 5. In addition, contact 12 having a second electric connection is connected to an end of first lead 6a, which is inserted into connector 5. First end 2a of electrical wire 2 is disposed between a first receiving portion formed at case 5a of connector 5 and a second receiving portion formed at contact 12, which is connected to first lead 6a. Second end 2b of electrical wire 2 is disposed between a third receiving portion formed at case 5a of connector 5 and a fourth receiving portion formed at contact 12, which is connected to second lead 6b. Thus, first end 2a and second end 2b of electrical wire 2 are connected to first lead 6a and second lead 6b, respectively.

[0005] Coil bobbin 3 is fixed to ring case 4 by a resin 13 (e.g., epoxy resin) which is poured into ring case 4 from an open end of the annular groove of ring case 4. O-ring 11, which is disposed between case 5a and the closed end of ring case 4, prevents resin 13 from leaking to the outside of the closed end surface of ring case 4 through the gap between projection portion 5a<sub>3</sub> of case 5a and a surrounding wall of opening 4a, when resin 13 is poured into ring case 4.

[0006] In the known electromagnet assembly 7 for use in an electromagnetic apparatus, it is necessary to secure first hooks 10a to ring-shaped plate 10 and to equip O-ring 11 when connector 5 is fixed to ring case 4. As a result, the efficiency during manufacturing of fixing connector 5 to ring case 4 may be reduced.

SUMMARY OF THE INVENTION

[0007] A need has arisen to provide an electromagnet assembly for use in an electromagnetic apparatus which has a greater manufacturing efficiency in fixing a connector to a ring case, when compared with a known electromagnet assembly.

5 [0008] In an embodiment of the present invention, an electromagnet assembly for an electromagnetic apparatus comprises a ring member, a coil bobbin, a ring case, and a connector. The ring member comprises a tubular spool, e.g., a cylindrical spool, with a pair of annular flanges projecting radially from the spool. The coil bobbin comprises the ring member and an electrical wire. The electrical wire is wound around the spool between the  
10 flanges. The ring case comprises an annular groove, which has an open edge. The coil bobbin is disposed in the ring case's annular groove. An opening is formed through the ring case adjacent to its closed end surface. A connector is disposed on the ring case adjacent to its closed end surface, such that the connector covers the opening. A first end and a second end of the electrical wire and a first lead wire and a second lead wire of an electric circuit are  
15 connected, respectively in the connector. A projection portion formed on the connector is inserted into the opening and is fixed adhesively to an end surface of the ring member.

[0009] In another embodiment of the present invention, an electromagnet assembly for an electromagnetic apparatus comprises a ring member, a coil bobbin, a ring case, and a connector. The ring member comprises a tubular spool, e.g., a cylindrical spool, with a pair  
20 of annular flanges projecting radially from the spool. The coil bobbin comprises the ring member and an electrical wire. The electrical wire is wound around the spool between the flanges. The ring case comprises an annular groove, which has an open edge. The coil bobbin is disposed in the ring case's annular groove. An opening is formed through the ring case adjacent to its closed end surface. A connector is disposed on the ring case adjacent to  
25 its closed end surface, such that the connector covers the opening. A first end and a second end of the electrical wire and a first and a second lead wire of an electric circuit are connected, respectively in the connector. A projection portion formed on an end surface of the ring member of the coil bobbin is inserted into the opening and is fixed adhesively to the connector.

30 [0010] Objects, features, and advantages will be apparent to persons of ordinary skill in the art from the following detailed description of the invention and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The present invention may be more readily understood with reference to the following drawings.

[0012] **Fig. 1** is a perspective and exploded view of a known electromagnet assembly  
5 for use in an electromagnetic apparatus.

[0013] **Fig. 2** is a longitudinal, cross-sectional view of a known compressor for use in an automotive air-conditioning system which includes an electromagnetic clutch having the known electromagnet assembly.

[0014] **Fig. 3** is a plan view of a closed end side of a ring case of the known  
10 electromagnet assembly.

[0015] **Fig. 4** is a cross-sectional view taken along the line IV-IV of **Fig. 3**.

[0016] **Fig. 5** is a cross-sectional view taken along the line V-V of **Fig. 4**.

[0017] **Fig. 6** is a cross-sectional view taken along the line VI-VI of **Fig. 4**.

[0018] **Fig. 7** is a plan view of a closed end side of a ring case of an electromagnet  
15 assembly for use in an electromagnetic apparatus, according to a first embodiment of the present invention.

[0019] **Fig. 8** is a cross-sectional view taken along the line VIII-VIII of **Fig. 7**.

[0020] **Fig. 9** is a cross-sectional view taken along the line IX-IX of **Fig. 8**.

[0021] **Fig. 10** is a cross-sectional view taken along the line X-X of **Fig. 8**.

[0022] **Fig. 11** is a cross-sectional view, which corresponds to **Fig. 8**, of an  
20 electromagnet assembly for use in an electromagnetic apparatus, according to a first alternative of the first embodiment of the present invention.

[0023] **Figs. 12 and 13** are cross-sectional views, which correspond to **Fig. 8**, of an  
25 electromagnet assembly for use in an electromagnetic apparatus, according to a second alternative of the first embodiment of the present invention.

[0024] **Fig. 14** is a cross-sectional view, which corresponds to **Fig. 8**, of an  
electromagnet assembly for use in an electromagnetic apparatus, according to a third alternative of the first embodiment of the present invention.

[0025] **Fig. 15** is a cross-sectional view, which corresponds to **Fig. 8**, of an electromagnet assembly for use in an electromagnetic apparatus, according to a fourth alternative of the first embodiment of the present invention.

[0026] **Fig. 16** is a cross-sectional view, which corresponds to **Fig. 8**, of an electromagnet assembly for use in an electromagnetic apparatus, according to a second embodiment of the present invention;

[0028] **Fig. 17** is a cross-sectional view taken along the line XVII-XVII of **Fig. 16**.

[0029] **Fig. 18** is a cross-sectional view taken along the line XVIII-XVIII of **Fig. 16**.

[0030] **Fig. 19** is a cross-sectional view, which corresponds to **Fig. 16**, of an electromagnet assembly for use in an electromagnetic apparatus, according to a first alternative of the second embodiment of the present invention.

[0031] **Fig. 20** is a cross-sectional view taken along the line XX-XX of **Fig. 19**.

[0032] **Fig. 21** is a cross-sectional view, which corresponds to **Fig. 16**, of an electromagnet assembly for use in an electromagnetic apparatus, according to a second alternative of the second embodiment of the present invention.

[0033] **Fig. 22** is a cross-sectional view, which corresponds to **Fig. 16**, of an electromagnet assembly for use in an electromagnetic apparatus, according to a third alternative of the second embodiment of the present invention.

[0034] **Figs. 23 and 24** are cross-sectional views, which correspond to **Fig. 16**, of an electromagnet assembly for use in an electromagnetic apparatus, according to a fourth alternative of the second embodiment of the present invention.

[0035] **Fig. 25** is a cross-sectional view, which corresponds to **Fig. 16**, of an electromagnet assembly for use in an electromagnetic apparatus, according to a fifth alternative of the second embodiment of the present invention.

[0036] **Fig. 26** is a cross-sectional view, which corresponds to **Fig. 16**, of an electromagnet assembly for use in an electromagnetic apparatus, according to a sixth alternative of the second embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0038] Referring to **Figs. 7-10**, a first embodiment of the present invention of an electromagnet assembly for use in an electromagnetic apparatus is shown. In the following explanation and **Figs. 7-10**, the same reference numbers are used to represent the same parts of an electromagnet assembly for use in an electromagnetic apparatus as shown in **Figs. 1-6**. Therefore, further explanation of similar parts is here omitted.

[0039] In an electromagnet assembly 17, according to this embodiment, a projection portion 15a<sub>3</sub> is formed on a case 15a of a connector 15, is pressedly fitted into an opening 4a formed through a ring case 4 adjacent to its closed end surface, and is fixed to an end surface of ring member 1 of a coil bobbin 3, e.g., by high frequency adhesion or ultrasonic adhesion or the like. Connector 15 is fixed to ring case 4 by which projection portion 15a<sub>3</sub> of case 15a of connector 15 is fixed adhesively to the end surface of ring member 1 of coil bobbin 3. Coil bobbin 3 is fixed within ring case 4 by resin, e.g., epoxy resin. A bottom surface of case 15a of connector 15 surrounds opening 4a and abuts ring case 4 adjacent to its closed end surface. Hooks 10a and an O-ring 11 of the known electromagnet assembly 7, which are shown in **Figs. 3 and 4**, are not part of electromagnet assembly 17. The structure of electromagnet assembly 17 is substantially the same as the known electromagnet assembly 7, except as described above.

[0040] In electromagnet assembly 17 for use in the electromagnetic apparatus, the engaging process for fixing a connector to a ring case is no longer necessary. Therefore, the manufacturing efficiency of fixing the connector to the ring case in the present invention may be increased compared with that of known electromagnet assemblies. Further, in electromagnet assembly 17, there is no gap between a side surface of projection portion 15a<sub>3</sub> of case 15a of connector 15 and an annular wall of opening 4a formed through ring case 4 adjacent to its closed end surface because projection portion 15a<sub>3</sub> of connector 15 is pressedly fitted into opening 4a of ring case 4. Consequently, this structure prevents the leakage of resin 13 to the outside of the closed end surface of ring case 4 through opening 4a when resin 13 is poured into ring case 4. As a result, in electromagnet assembly 17, the manufacturing process for placing of O-ring 11 of known electromagnet assembly 7 is no longer necessary, and the manufacturing efficiency of fixing a connector to a ring case in the present invention may be increased compared with that of known electromagnet assemblies. Further, because the number of parts of electromagnet assembly 17 is reduced compared with

the known electromagnet assembly, the manufacturing cost of electromagnet assembly 17 may be reduced compared with that of known electromagnet assemblies.

[0041] Referring to **Fig. 11**, in a first alternative to the first embodiment of the present invention, hook portion 15a<sub>4</sub> may be formed around a tip portion of projection portion 15a<sub>3</sub>, and hook portion 15a<sub>4</sub> may be pressedly fitted into opening 4a formed through ring case 4 adjacent to its closed end surface and may engage a rim of opening 4a. As a result, hook portion 15a<sub>4</sub> closes the entrance of the gap between the side surface of projection portion 15a<sub>3</sub> of connector 15 and an annular wall of opening 4a, and when resin 13 is poured into ring case 4, the leakage of resin 13 to the outside of the closed end surface of ring case 4 through opening 4a may be prevented. Further, in the first embodiment of the present invention, a bond may be coated to the side surface of projection portion 15a<sub>3</sub>, and the side surface of projection portion 15a<sub>3</sub> may be fixed adhesively to the annular wall of opening 4a. As a result, the gap between the side surface of projection portion 15a<sub>3</sub> and the annular wall of opening 4a is closed by the bond, and when resin 13 is poured into ring case 4, the leakage of resin 13 to the outside of the closed end surface of ring case 4 through opening 4a may be prevented.

[0042] Referring to **Figs. 12 and 13**, in a second alternative to the first embodiment of the present invention, a second projection portion 15a<sub>5</sub> may be formed around a first projection portion 15a<sub>3</sub> of case 15a of connector 15, and second projection portion 15a<sub>5</sub> may engage a concave portion 4a<sub>1</sub> formed around the annular wall of opening 4a of ring case 4. Second projection portion 15a<sub>5</sub> of case 15a may be fixed to concave portion 4a<sub>1</sub> formed around the annular wall of opening 4a of ring case 4, e.g., by high frequency adhesion or ultrasonic adhesion or the like. An annular projection portion 15a<sub>6</sub> may be formed on the first end surface of case 15a, and annular projection portion 15a<sub>6</sub> may engage an annular concave portion 4a<sub>2</sub> formed on the closed end surface of ring case 4. Annular projection portion 15a<sub>6</sub> of case 15a is fixed to annular concave portion 4a<sub>2</sub> formed on the closed end surface of ring case 4, e.g., by high frequency adhesion or ultrasonic adhesion or the like. A plurality of third projection portions 15a<sub>7</sub> may be formed on the tip portion of first projection portion 15a<sub>3</sub> of case 15a, and the plurality of third projection portions 15a<sub>7</sub> may abut the end surface of ring member 1. The plurality of third projection portions 15a<sub>7</sub> of the tip portion of

first projection portion 15a<sub>3</sub> of case 15a may be fixed to the end surface of ring member 1, e.g., by high frequency adhesion or ultrasonic adhesion or the like. As shown in **Figs. 12 and 13**, second projection portion 15a<sub>5</sub>, concave portion 4a<sub>1</sub>, annular projection portion 15a<sub>6</sub>, annular concave portion 4a<sub>2</sub>, and third projection portions 15a<sub>7</sub> may have a variety of cross-sectional shapes. As a result, in electromagnet assembly 17, the manufacturing process for placing of O-ring 11 of known electromagnet assembly 7, and the engaging process for fixing connector 15 to ring case 4 are no longer necessary, and the manufacturing efficiency of fixing a connector to a ring case in the present invention may be increased compared with that of known electromagnet assemblies. Further, in this alternative to the first embodiment, second projection portion 15a<sub>5</sub> may be formed by a concave portion, and concave portion 4a<sub>1</sub> may be formed by a projection portion, which engages second portion 15a<sub>5</sub>. Annular projection portion 15a<sub>6</sub> may be formed by a annular concave portion, and annular concave portion 4a<sub>2</sub> may be formed by an annular projection portion, which engages annular portion 15a<sub>6</sub>.

[0043] Referring to **Fig. 14**, in a third alternative to the first embodiment of the present invention, a notched portion 15a<sub>8</sub> may be formed at first projection portion 15a<sub>3</sub> of case 15a of connector 15, and first projection portion 15a<sub>3</sub> may be pressedly fitted into opening 4a formed through ring case 4 adjacent to its closed end surface. Hook portion 15a<sub>4</sub> may be formed around a tip portion of first projection portion 15a<sub>3</sub>, and may engage a rim of opening 4a of ring case 4. A plurality of third projection portions 15a<sub>7</sub> may be formed on the tip portion of first projection portion 15a<sub>3</sub> of case 15a, and the plurality of third projection portions 15a<sub>7</sub> may abut the end surface of ring member 1. First projection portion 15a<sub>3</sub> of case 15a of connector 15 may be fixed to the end surface of ring member 1, e.g., by high frequency adhesion or ultrasonic adhesion or the like. Moreover, a plurality of concave portion may be formed on the end surface of ring member 1, and may engage the plurality of third projection portions 15a<sub>7</sub>. As a result, in electromagnet assembly 17, the manufacturing process for placing of O-ring 11 of known electromagnet assembly 7, and the engaging process for fixing connector 15 to ring case 4 are no longer necessary, and the manufacturing efficiency of fixing a connector to a ring case in the present invention may be increased compared with that of known electromagnet assemblies.

[0044] Referring to **Fig. 15**, in a fourth alternative to the first embodiment of the present invention, a second projection portion 15a<sub>5</sub> may be formed around first projection portion 15a<sub>3</sub> of case 15a of connector 15. A concave portion 4a<sub>1</sub> may be formed around the annular wall of opening 4a formed through ring case 4 adjacent to its closed end surface.

5 First projection portion 15a<sub>3</sub> of case 15a is pressedly fitted into opening 4a, and second projection portion 15a<sub>5</sub> may engage concave portion 4a<sub>1</sub> of ring case 4. A plurality of third projection portions 15a<sub>7</sub> may be formed on the tip portion of first projection portion 15a<sub>3</sub> of case 15a, and may abut the end surface of ring member 1. First projection portion 15a<sub>3</sub> of case 15a may be fixed to the end surface of ring member 1, e.g., by high frequency adhesion or ultrasonic adhesion or the like. Moreover, a plurality of concave portion may be formed on the end surface of ring member 1, and may engage the plurality of third projection portions 15a<sub>7</sub>. As a result, in electromagnet assembly 17, the manufacturing process for placing of O-ring 11 of known electromagnet assembly 7, and the engaging process for fixing connector 15 to ring case 4 are no longer necessary, and the manufacturing efficiency of fixing a connector to a ring case in the present invention may be increased compared with that of known electromagnet assemblies. Further, in this alternative to the first embodiment, second projection portion 15a<sub>5</sub> may be formed by a concave portion, and concave portion 4a<sub>1</sub> may be formed by a projection portion, which engages second projection portion 15a<sub>5</sub>.

[0045] Referring to **Figs. 16-18**, a second embodiment of the present invention of an electromagnet assembly for use in an electromagnetic apparatus is shown. In the following explanation and **Figs. 16-18**, the same reference numbers are used to represent the same parts of electromagnet assembly 7 as shown in **Figs. 1-6**. Therefore, further explanation of similar parts here is omitted.

[0046] In electromagnet assembly 27, according to this embodiment, a projection portion 21b, is formed on an end surface of a ring member 21 of a coil bobbin 23, is pressedly fitted into an opening 4a formed through a ring case 4 adjacent to its closed end surface, and is fixed to a case 25a of a connector 25, e.g., by high frequency adhesion or ultrasonic adhesion or the like. Connector 25 is fixed to ring case 4 by which case 25a is fixed adhesively to projection portion 21b formed on the end surface of a ring member 21 of a coil bobbin 23. Coil bobbin 23 is fixed within ring case 4 by resin, e.g., epoxy resin. A bottom surface of case 25a of connector 25 surrounds opening 4a and abuts ring case 4 adjacent to its closed end surface. Hooks 10a and an O-ring 11 of the known electromagnet

assembly, which are shown in **Figs. 3 and 4**, are not part of electromagnet assembly 27. The structure of electromagnet assembly 27 is substantially the same as the known electromagnet assembly 7, except as described above.

[0047] In electromagnet assembly 27, the engaging process for fixing connector 25 to ring case 4 is no longer necessary. Therefore, the manufacturing efficiency of fixing a connector to a ring case in the present invention may be increased compared with that of known electromagnet assemblies. Further, in electromagnet assembly 27, projection portion 21b, which is formed on an end surface of a ring member 21 of a coil bobbin 23, is pressedly fitted into an opening 4a formed through a ring case 4 adjacent to its closed end surface, and is fixed to a case 25a of a connector 25. Consequently, this structure prevents the leakage of resin 13 to the outside of the closed end surface of ring case 4 through opening 4a when resin 13 is poured into ring case 4, because there is no gap between the side surface of projection portion 21b and the annular wall of opening 4a. As a result, in electromagnet assembly 27, the manufacturing process for placing of O-ring 11 of known electromagnet assembly 7 is no longer necessary, and the manufacturing efficiency of fixing a connector to a ring case in the present invention may be increased compared with that of known electromagnet assemblies. Further, because the number of parts of electromagnet assembly 27 is reduced compared with known electromagnet assemblies, the manufacturing cost of electromagnet assembly 27 may be reduced compared with that of known electromagnet assemblies. Moreover, in the second embodiment of the present invention, a bond may be coated to the side surface of projection portion 21b, and the side surface of projection portion 21b may be fixed adhesively to the annular wall of opening 4a. As a result, the gap between the side surface of projection portion 21b and the annular wall of opening 4a is closed by the bond, and when resin 13 is poured into ring case 4, the leakage of resin 13 to the outside of the closed end surface of ring case 4 through opening 4a may be prevented.

[0048] Referring to **Figs. 19 and 20**, in a first alternative to the second embodiment of the present invention, a projection portion 25a<sub>4</sub> is formed on case 25a of connector 25 and may be fitted into a concave portion 21b<sub>1</sub>, which is formed on a first projection portion 21b of coil bobbin 23. As a result, adhesion surfaces between projection portion 21b and case 25a are increased, and the strength with which connector 25 is fixed to ring case 4, may be increased. Projection portion 25a<sub>4</sub> may have a variety of cross-sectional shapes. Moreover, projection portion 25a<sub>4</sub> may be a single projection or a plurality of projections.

[0049] Referring to **Fig. 21**, in a second alternative to the second embodiment of the present invention, a second projection portion 21b<sub>2</sub> is formed on a tip portion of a first projection portion 21b and may be fitted into a concave portion 25a<sub>5</sub>, which is formed on case 25a of connector 25. As a result, adhesion surfaces of between projection portion 21b and case 25a are increased, and the strength with which connector 25 is fixed to ring case 4, may be increased. Second projection portion 21b<sub>2</sub> may have a variety of cross-sectional shapes. Moreover, second projection portion 21b<sub>2</sub> may be a single projection or a plurality of projections.

[0050] Referring to **Fig. 22**, in a third alternative to the second embodiment of the present invention, a tip portion of first projection portion 21b of coil bobbin 23 may be fitted into a concave portion 25a<sub>6</sub> formed on case 25a of connector 25. As a result, adhesion surfaces between projection portion 21b and case 25a are increased, and the strength with which connector 25 is fixed to ring case 4, may be increased.

[0051] Referring to **Figs. 23 and 24**, in a fourth alternative to the second embodiment of the present invention, a second projection portion 21b<sub>3</sub> may be formed around a first projection portion 21b of ring member 21 of coil bobbin 23, and a concave portion 4a<sub>1</sub> may be formed around the annular wall of opening 4a of ring case 4. Second projection portion 21b<sub>3</sub> of ring member 21 of coil bobbin 23 may engage a concave portion 4a<sub>1</sub> of opening 4a of ring case 4, and ring member 21 of coil bobbin 23 may be fixed to ring case 4, e.g., by high frequency adhesion or ultrasonic adhesion or the like. A plurality of third projection portions 21b<sub>2</sub> may be formed on a tip portion of first projection portion 21b of ring member 21 of coil bobbin 23, and a plurality of concave portions 25a<sub>5</sub> may be formed on the first end surface of case 25a of connector 25. The plurality of third projection portions 21b<sub>2</sub> may engage the plurality of concave portions 25a<sub>5</sub> of the first end surface of case 25a of connector 25, and coil bobbin 23 may be fixed to case 25a of connector 25, e.g., by high frequency adhesion or an ultrasonic adhesion or the like. As a result, in electromagnet assembly 27, the manufacturing process for placing of O-ring 11 of known electromagnet assembly 7, and the engaging process for fixing connector 25 to ring case 4 are no longer necessary, and the manufacturing efficiency of fixing a connector to a ring case in the present invention may be increased compared with that of known electromagnet assemblies. As shown in **Figs. 23 and 24**, second projection portion 21b<sub>3</sub>, concave portion 4a<sub>1</sub>, third projection portions 21b<sub>2</sub>, and

concave portions 25a<sub>5</sub> may have a variety of cross-sectional shapes. Further, in this alternative to the second embodiment, second projection portion 21b<sub>3</sub> may be formed by a concave portion, and concave portion 4a<sub>1</sub> may be formed by a projection portion, which engages projection portion 21b<sub>3</sub>. Third projection portions 21b<sub>2</sub> may be formed by concave portions, and concave portions 25a<sub>5</sub> may be formed by projection portions, which engage third projection portions 21b<sub>2</sub>.

[0052] Referring to **Fig. 25**, in a fifth alternative to the second embodiment of the present invention, a notched portion 21b<sub>4</sub> may be formed at first projection portion 21b of ring member 21 of coil bobbin 23, and first projection portion 21b may be pressedly fitted into opening 4a formed through ring case 4 adjacent to its closed end surface. A hook portion 21b<sub>5</sub> may be formed around a tip portion of first projection portion 21b, and may engage a rim of opening 4a of ring case 4. A plurality of second projection portions 21b<sub>2</sub> may be formed on the tip portion of first projection portion 21b of ring member 21 of coil bobbin 23, and the plurality of second projection portions 21b<sub>2</sub> may engage a plurality of concave portions 25a<sub>5</sub>, which may be formed on the first end surface of case 25a of connector 25. Case 25a of connector 25 may be fixed to ring member 21 of coil bobbin 23, e.g., by high frequency adhesion or ultrasonic adhesion or the like. As a result, in electromagnet assembly 27, the manufacturing process for placing of O-ring 11 of known electromagnet assembly 7, and the engaging process for fixing connector 25 to ring case 4 are no longer necessary, and the manufacturing efficiency of fixing a connector to a ring case in the present invention may be increased compared with that of known electromagnet assemblies. Second projection portions 21b<sub>2</sub> and concave portions 25a<sub>5</sub> may have a variety of cross-sectional shapes.

[0053] Referring to **Fig. 26**, in a sixth alternative to the second embodiment of the present invention, a second projection portion 21b<sub>3</sub> may be formed around first projection portion 21b of ring member 21 of coil bobbin 23. A concave portion 4a<sub>1</sub> may be formed around the annular wall of opening 4a formed through ring case 4 adjacent to its closed end surface. First projection portion 21b is pressedly fitted into opening 4a, and second projection portion 21b<sub>3</sub> may engage concave portion 4a<sub>1</sub> of ring case 4. A plurality of third projection portions 21b<sub>2</sub> may be formed on the tip portion of first projection portion 21b of ring member 21 of coil bobbin 23, and may engage a plurality of concave portions 25a<sub>5</sub>, which may be formed on the first end surface of case 25a of connector 25. Case 25a of

connector 25 may be fixed to first projection portion 21b of ring member 21 of coil bobbin 23, e.g., by high frequency adhesion or ultrasonic adhesion or the like. As a result, in electromagnet assembly 27, the manufacturing process for placing of O-ring 11 of known electromagnet assembly 7, and the engaging process for fixing connector 25 to ring case 4 are no longer necessary, and the manufacturing efficiency of fixing a connector to a ring case in the present invention may be increased compared with that of known electromagnet assemblies. Further, in this alternative to the second embodiment, second projection portion 21b<sub>3</sub> may be formed by a concave portion, and concave portion 4a<sub>1</sub> may be formed by a projection portion, which engages second projection portion 21b<sub>3</sub>. Similarly, third projection portions 21b<sub>2</sub> may be formed by convex portions, and concave portions 25a<sub>5</sub> may be formed by projection portions, which engage third projection portions 21b<sub>2</sub>. Moreover, second projection portion 21b<sub>3</sub>, concave portion 4a<sub>1</sub>, third projection portions 21b<sub>2</sub>, and concave portions 25a<sub>5</sub> may have a variety of cross-sectional shapes.

[0054] As described above, with respect to embodiments of the present invention of an electromagnet assembly for use in an electromagnetic apparatus, a projection portion formed on a connector is inserted into an opening formed through a ring case adjacent to its closed end surface. The connector is fixed adhesively to an end surface of a ring member of a coil bobbin, or a projection portion formed on an end surface of a ring member of a coil bobbin is inserted into an opening formed through a ring case adjacent to its closed end surface. If the ring member is inserted into an opening, it may be fixed adhesively to a case of a connector. As a result, the connector is fixed to the coil bobbin, which is fixed to the ring case, without an engaging process, and the connector is fixed to the ring case. Therefore, the engaging process is no longer necessary, and the manufacturing efficiency of fixing the connector to the ring case may be increased as compared with that of a known electromagnet assemblies.

[0055] Although the present invention has been described in connection with preferred embodiments, the invention is not limited thereto. It will be understood by those skilled in the art that variations and modifications may be made within the scope and spirit of this invention, as defined by the following claims.